Modified Seam Carving by Changing Resizing Depending on the Object Size in Time and Space Domains

Kohei Arai
Graduate School of Science and Engineering
Saga University, Saga City, Japan

***Abstract*—Modified seam carving by switching from the conventional method to resizing method depending on the object size is proposed. When the object size is dominant in the scene of interest, the conventional seam carving shows deformation of components in the object. To avoid the situation, resizing method is applied rather than the conventional seam carving in the proposed method. Also, the method for video data compression based on the seam carving not only in image space domain but also in time domain is proposed. It is specific feature that original quality of video picture can be displayed when it is replayed. Using frame to frame similarity defined with histograms distance between the neighboring frames, frames which have great similarity can be carved results in data is compressed in time domain. Moreover, such carved frame can be recorded in the frame header so that the carved frame can be recovered in reproducing the compressed video. Thus, video quality can be maintained, no degradation of video quality at all. Compression ratio is assessed with the several video data. It is obvious that data compression ratio of the proposed space and time domain seam carving is greater than that of the conventional space domain seam carving.**

Keywords—Seam carving; data compression in time and space domains; video data compression

I. INTRODUCTION

Image data compression methods which allow compression using removing content less portion of image from original images (Seam Carving[1]) are proposed [1]- [8]. Seam carving with OpenCV, Python, and scikit-image[2] is available. The graph cut concept was proposed together with dynamic graph cut based on Markov random fields [7]. These methods allow image segmentation, texture extraction, image mosaic, image energy minimization, etc. Also, video cutout method is proposed for targeting an image portion through panning and scanning together with a content based video retargeting [9]. Then content resizing based method of the well-known seam carving is proposed [10]. Furthermore, video carving method is proposed [11] together with acceleration algorithm for video carving [12]. These methods are referred to "the conventional seam carving method (See Appendix).

Seam carving is supported by Adobe[3], GIMP[4], digiKam[5] and Image Magick[6] already [2]. Video carving allows targeting to content rich time periods in the video stream so that video content is shortened. Meanwhile, some portions of time series of video contents are deleted so that not natural object movement appears some time.

Video carving method proposed here is based on the distance between histograms of the objects in concern in the two adjacent frames, the current frame and the next frame. If the distance is not less than a prior determined threshold, then such frame can be deleted for video data compression. Also, the deleted frame number is stored in the header of the video content so that object movement is much natural in playing the compressed video contents by referring the deleted frames (the deleted frame is replaced to the previous frame) in comparison to the conventional video carving method [13]. On the other hand, improved seam carving by switching from the conventional method to resizing method depending on the object size is proposed. When the object size is dominant, the conventional seam carving shows deformation of components in the object. Sometimes it would be fanny shapes of the objects. To avoid the situation, image size change method is applied rather than the conventional seam carving in the proposed method.

The method proposed here is preprocessing of the object size detection before applying space domain of seam carving. If the object size is dominant in the whole image, object shape cannot be maintained its shape is the conventional seam carving applied to the image of concern. To avoid the situation, object size is detected prior to the seam carving in the proposed method. Also, it is possible to compress the video data in concern by considering the object moving speed. If the moving speed is below a threshold, then such frames can be removed. It is called time domain seam carving in the proposed method.

The following section describes the proposed method followed by some experimental results with video contents. Finally, conclusions with some discussions are described.

1 https://www.pyimagesearch.com/2017/01/23/seam-carving-with-opencv-python-and-scikit-image/

2 https://scikit-image.org/

3 https://www.adobe.com/

4 https://www.gimp.org/

5 https://www.digikam.org/

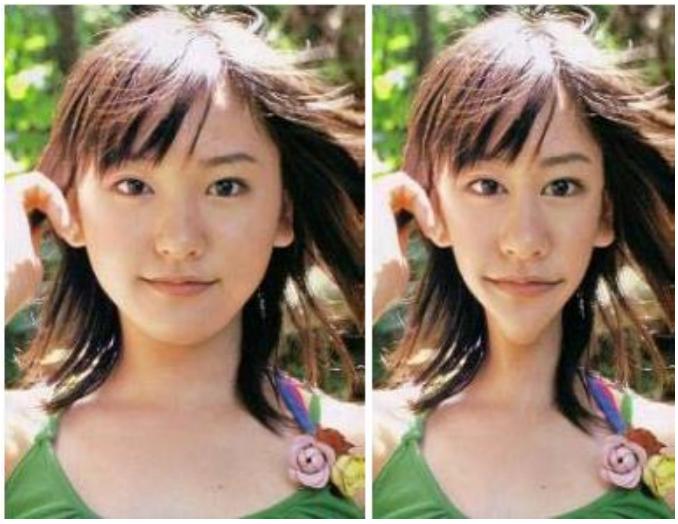
6 https://imagemagick.org/index.php

II. Proposed Method

A. Proposed Seam Carving Method

It is not always that the conventional space domain seam carving works well. If the major portion of image which must be maintained is shared dominantly in the almost over the original image, then seam carving does not work as is shown in Fig. 1, namely, the object size is dominant in the image, the conventional seam carving method shows such like very fanny object image shown in Fig. 1. To avoid such situation, the preprocessing which is shown in Fig. 2 is proposed.

If the approximated circle or rectangle shares dominant area of the image in concern, then seam carving is applied to the entire image and if not, then seam carving is applied to the rest of the image. Example of the edge detected result of the image of Fig. 1 is shown in Fig. 3(a). Fig. 3(b) shows the approximated edge image with ellipsoids.



(a) Original Image (b) Seam carved image

Fig. 1. Image after the Seam Carving Referring to Energy List and m List in Accordance with the Conventional Seam Carving Algorithm.

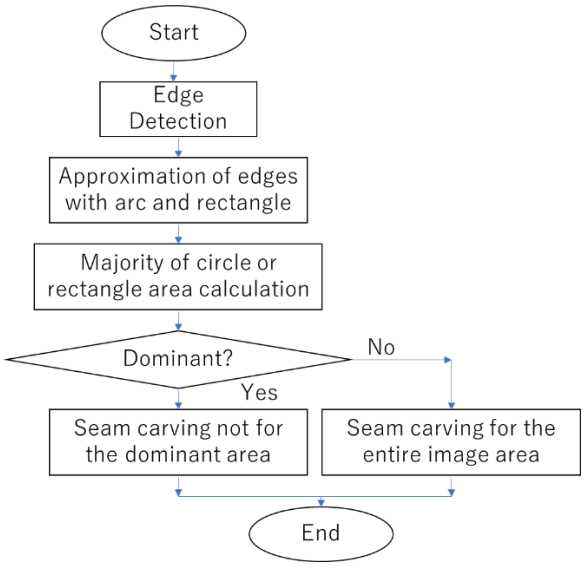


Fig. 2. Proposed Preprocessing for Seam Carving in Spatial Domain.

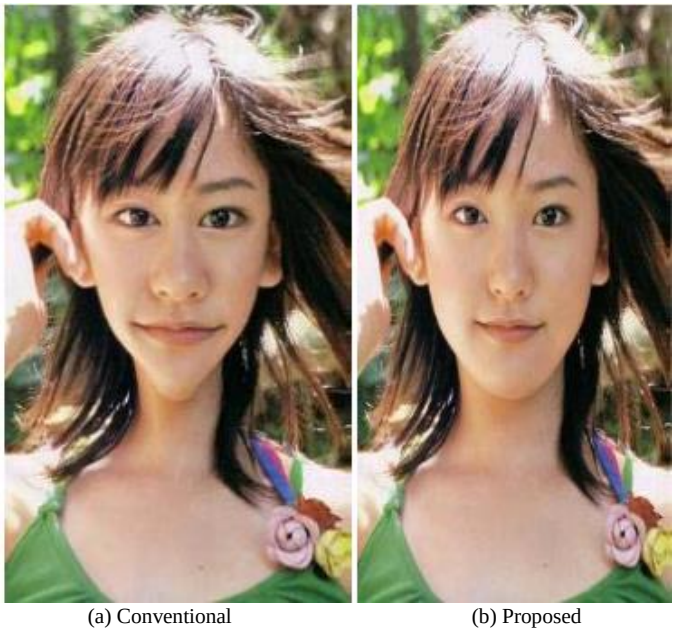
(a) Edge detected image (b) Approximated with ellipsoids

Fig. 3. Example of the Edge Detected Result of the Image of Fig. 1.

In this case, resizing method is applied to the object image. Namely, image aspect ratio is changed depending on the designated compression ratio. Then interpolation is applied to the resized image when it is reproduced. Therefore, original shapes of objects are maintained when it is reproduced. The reproduced images with the conventional and the proposed seam carving methods are shown in Fig. 4. It is obvious that the reproduced image with the proposed seam carving method is much natural than that with the conventional method. The compression ratio of the proposed method is almost same comparing to that of the conventional method.

B. Proposed Space and Time Domain Seam Carving

The proposed video seam carving method applies another seam carving in time domain. Process flow of the proposed time domain seam carving is shown in Fig. 5. Objected regions are already selected in the space domain seam carving.



(a) Conventional (b) Proposed

Fig. 4. Reproduced Images with the Conventional and the Proposed Seam Carving Methods.

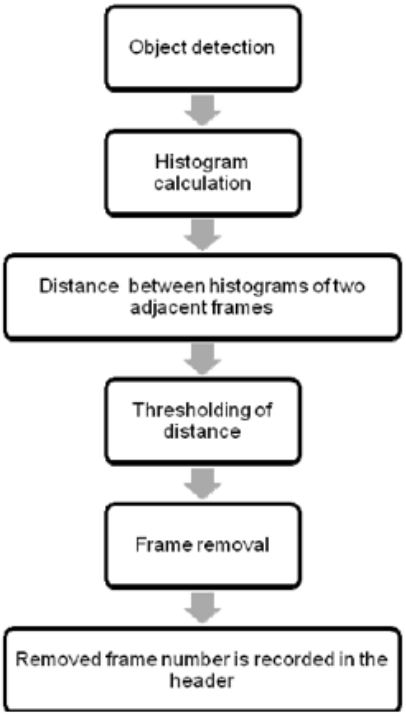


Fig. 5. Process Flow of the Time Domain Seam Carving.

Object shape is changed in natural by frame by frame because the object moves typically. The proposed method uses object image histogram change between two adjacent frames. It is assumed that histograms between two adjacent frames are not changed then such two frames are redundant so that it may be removed because such frames are redundant.

Contour of the object can be defined after the object detection. Then histogram of intensity component of the detected object is calculated after the RGB to HIS conversion process. After that comparison of current histogram and the previous histogram is made. Histogram distance is defined with Bhachattaryya distance[7], D which is expressed as follows [14]:

$$D = \sum_{i=1}^{256} \sqrt{p_i q_i} \quad (1)$$

where p and q denote frequency of the intensity i for the current and the previous object images. By removing the frames which have a small D, under a prior determined threshold, data compression can be done. The removed frame number is recorded in the header. For instance, bitmap image format has 14 byte of header region. In the region, there is two byte of file type information followed by four byte of file size information. Then two sets of two byte of preserved regions are followed by together with four bytes of offset information.

In the preserved region, it is possible to put in the information of the removed frames. By using this information, it can be refrained the previous frames when it is played onto display.

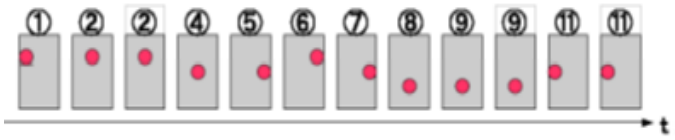


Fig. 6. Procedure of the Proposed Time Domain Seam Carving Method.

Because the conventional video carving makes shortened the video contents in time domain, it may give some strange impressions of object movement. Meanwhile, the proposed time domain seam carving does not give such an impression at all. Fig. 6 shows illustrative schematic view of the proposed time domain seam carving.

Red circle shows the extracted object. Histogram of the intensity of the pixels in the contour of the extracted object is calculated followed by Bhachattaryya distance between histogram calculations. Then the distance D is below threshold, in this case, the frame number 2 and 3, 9 and 10 as well as 11 and 12 of D are below threshold so that the frame number 3, 10 and 12 are removed. Then compressed data, in this case, compression ratio is 3/4 is stored together with the removed frame numbers in the header. When the stored compressed video data is played, the removed frames are added to the compressed video content so that the object movement is somewhat natural. Therefore, the proposed method is for storage volume saving not for time saving.

C. Specific Feature of the Proposed Space and Time Domain Seam Carving

The most specific feature of the proposed method is that space and time domain seam carving portions can be coded and stored in the storage memory. The information of seam carving portion can be stored in the header information of coded video picture. Therefore, original video picture can be replayed referring to the seam carving portions in the storage memory.

III. Experiments

A. Space Domain Seam Carving

Fig. 7 shows the procedure of the proposed space domain seam carving method. Red circle indicates object which is detected with OpenCV library of cascade of boosted classifiers based on Haar-like features[8] which is provided by

OpenCV library of CvHaarFeature, CvHaarClassifier,

CvHaarStageClassifier, CvHaarClassifierCascade.

Then object can be tracked by frame by frame. The detected object is meaning full so that it is remained through space domain seam carving while the background is removed by the space domain seam carving. The rectangle areas in the time series of image data after the space domain seam carving show the detected object. Location of the detected object can be stored so that space domain seam carving can easily be done.

[7] https://en.wikipedia.org/wiki/Bhattacharyya_distance

[8] https://algorithm.joho.info/image-processing/haar-like-feature-value/

Fig. 8 shows the test image generated with the sphere function provided by the well-known free software of the PovRay[9] of computer graphic software tool [15]. 45 frames of 512 by 384 pixels of test images are created. The location of object is changed by frame by frame. Fig. 9 shows the process flow of the proposed space domain seam carving method.

Object detection in the case is easy because only thing OpenCV must do is to detect "Sphere". Using the simulated time series of test image, data compression ratio is evaluated.

The experimental results of space domain seam carving are as follows:

Image size: 512 by 384 pixels→100 by 100 pixels

Data volume a frame: 576KB→48KB

The number of frames: 45→45

Data volume after the space domain seam carving: 26MB →2.6MB

In this case, 1/10 of data compression is confirmed with same image quality.

B. Time Domain Seam Carving

The experiments with two video contents which are shown in Fig. 10 are conducted. Fig. 10(a) is the video of the remains in Greek and (b) the video the man walking the street situated in front of big trees. Old remain is captured from the different aspect angles so that not only clouds in the background but also object of the old remain is changed in shape together with shadow in the scene number 1. Meanwhile, the walking man of the scene number 2 moves from right hand side to left direction so that not only waving leaves of the big trees by the winds but also the man is changed in location together with their shadows.

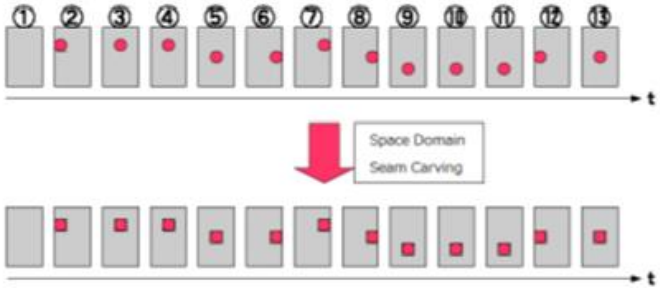


Fig. 7. Procedure of the Proposed Space Domain Seam Carving Method.

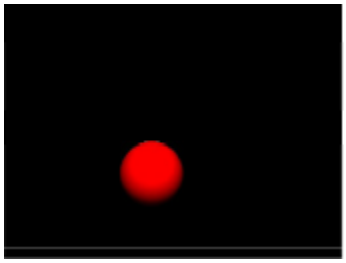


Fig. 8. Simulated Test Image for Evaluation of Data Compression Ratio of the Proposed Space Domain Seam Carving (Image Size is 512 by 384 Pixels).

[9] http://www.povray.org/download/

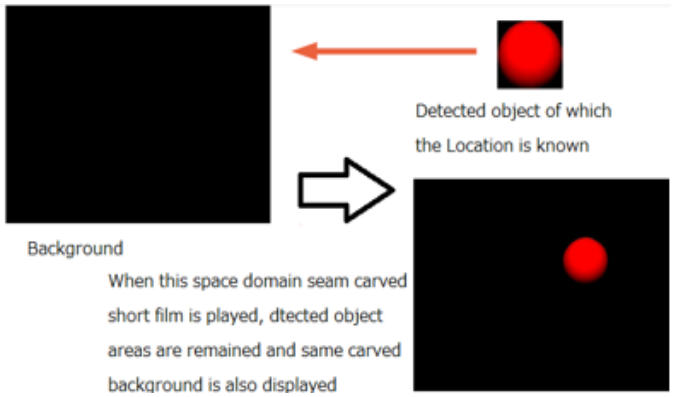
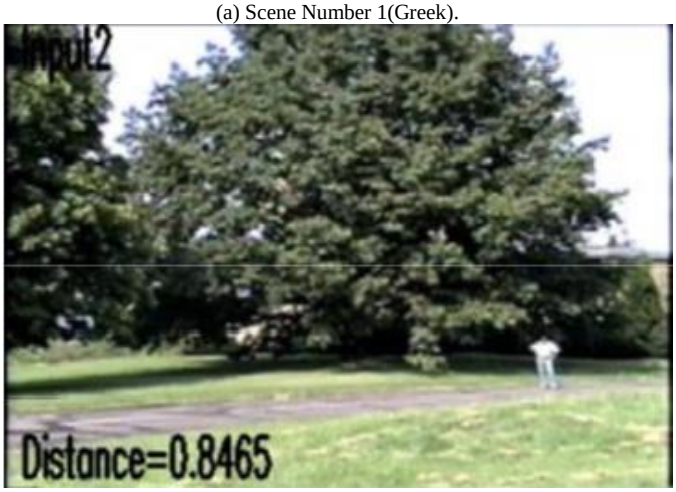


Fig. 9. Process Flow of the Proposed Space Domain Seam Carving.

(a) Scene Number 1(Greek).



(b) Scene Number 2(Walking).

Fig. 10. Test Scenes used for Evaluation of Data.

Results of moving picture data compression for test scene number 1 is as follows:

Image size: 244 by 360 pixels

Data volume a frame: 257KB

Threshold: 0.0479

The number of removed frames: 22 frames out of 132 frames so that 11/61 of data compression ratio is accomplished which is corresponding to the compressed data volume of 5654KB. On the other hand, the results of moving picture data compression for test scene number 2 is as follows,

Image size: 240 by 360 pixels

Data volume a frame: 253KB

Threshold: 0.0435

The number of removed frames: 47 frames out of 182 frames so that 47/182 of data compression ratio is accomplished in this case which is corresponding to the compressed data volume of 11891KB.

The conventional video seam carving requires much shorter time for play the compressed video with a little bit funny impression. Meanwhile, the proposed time domain seam carving requires the completely same time for play the compressed video without any defect because the removed or carved frames are replaced with the previous frame in concern.

IV. Conclusion

It is confirmed that the proposed video seam carving method is effective; in particular, time domain seam carving achieves around 1/5-1/6 of data compression ratio. It is obvious that the data compression ratio depends on the changes in the moving pictures. Once the object is detected with OpenCV library through training with the objective moving picture itself, then time domain seam carving is performed effectively.

The conventional image space domain seam carving by resizing algorithm shows 1/2-1/10 of data compression ratio depending on redundant image areas in the background in the image. Therefore, 1/10-1/600 of significantly high data compression can be achieved with a slight image degradation if the proposed space and time domain seam carving data compression is applied.

The specific feature of the proposed time domain seam carving is that it requires the completely same time for play the compressed video without any defect because the removed or carved frames are replaced with the previous frame in concern.

Further experimental studies are required for validation of the proposed seam carving method in time and space domains.

Appendix: Conventional Space Domain Seam Carving

Firstly, seam carving is assumed to be applied to the video contents in image space domain already. In the space domain seam carving, objected image portion is extracted first. The method for object extraction is used to be based on OpenCV library [13]. How-to build a cascade of boosted classifiers based on Haar-like features is provided by OpenCV library of.

CvHaarFeature, CvHaarClassifier, CvHaarStageClassifier, CvHaarClassifierCascade.

Then the energy concentration in the other image regions is calculated for seam carving. Poor energy regions, then, are removed after that. This procedure is the conventional seam carving method. An example of the conventional image space seam carving is shown in Fig. 11. In this case, 400 by 300 pixels of the original image are resized in 200 by 300 pixels. It is also possible to determine remaining objects and removing objects. In this example, the green portion of image would like to be remained while the red portion of image would like to be removed. Thus, image is resized results in image data compression.

There are some web sites which allow space domain seam carving. Using web site provided seam carving tool, image resizing based on space domain seam carving can be done. Fig. 12 shows an example of seam carving image resizing through the web site.

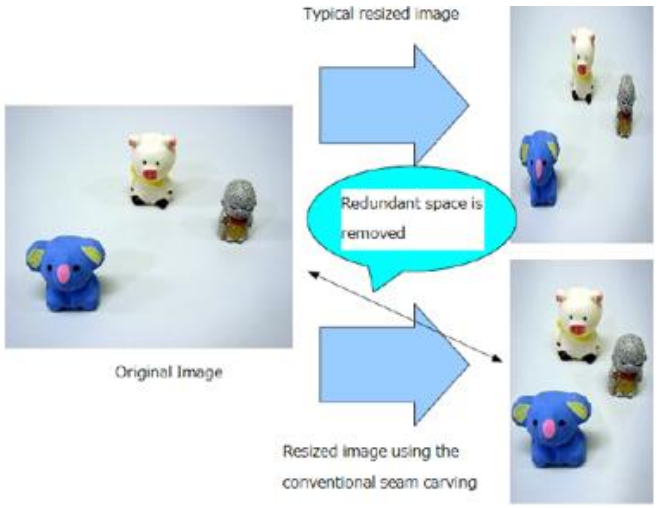


Fig. 11. Example of the Conventional Image Space Domain of Seam Carving.

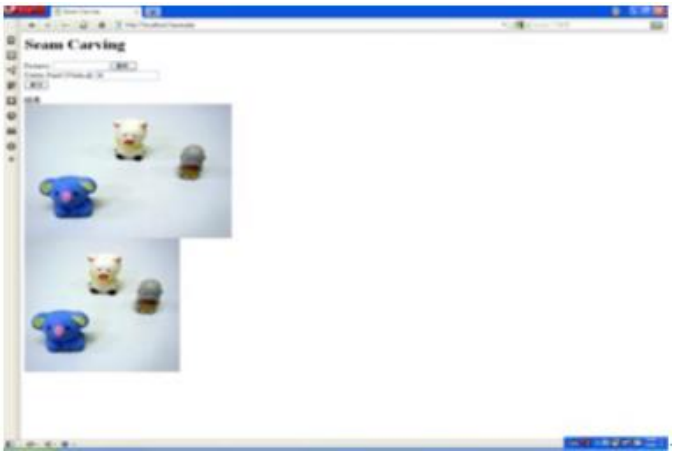


Fig. 12. Example of Seam Carving Image Resizing through the Web Site.

Space domain seam carving allows image resizing with some intentional conditions. From the web site of Dr. Arial Shamir's paper derived PHP top page, Micro Soft Windows version of space domain seam carving tool is created.

The algorithm is as follows:

1) Get the original image together with the image size
2) Get the color index of each pixel in the image
3) Calculate energy list using Euclidian distance between the color index of the pixel in concern and the four neighboring pixels shown in Fig. 13.
4) Take an average over Euclidian distance between pixel #1 and #4 and that between #1 and #5 results in a distance in vertical direction.
5) Take an average over Euclidian distance between pixel #1 and #2 and that between #1 and #3 results in a distance in horizontal direction.
6) Replace the pixel value of concern (#1) with summation of the distances in vertical and horizontal directions

Then energy list is converted to the m list as follows:

①'=①+min(⑦,⑧)
②'=②+min(⑦,⑧,⑨)
⑥'=⑥+min(⑪,⑫)
⑧'=⑧+min(⑬,⑭,⑮)

Where the pixels in the m list is aligned as shown in Fig. 14.

Thus, y pixels in the m list are calculated. To identify the pixels for seam carving, the following algorithm is applied to the m list,

1) Extract minimum value of pixel in the calculated max_y
↓
2) From the max_y-1, the following calculation is made
m_list[x][max_y-1] energy_list[x][max_y-1]
↓
3) The result is corresponding to the following two candidates:

m_list[x-1] [max_y-2], m_list[x][max_y-2],

m_list[x+1] [max_y-2]

4) Go back to (2), and refrain the process (3), then the seam carving portion is extracted referencing to energy list and m list like as shown in Fig. 15.

In the above figure, green line shows the highest energy. Low energy pixel which is situated at the far from the highest energy pixel is removed by seam carving. It looks like an onion pealing. Other examples are shown in Fig. 16.

Fig. 17 shows an example of image resizing with intentional condition on whether remove the image portions. In this case, the green rectangle in Fig. 17(b) shows the image portion which must be remained while the red rectangle is the image portion which must be removed. Thus, resultant image of Fig. 17(c) is reduced with space domain seam carving.

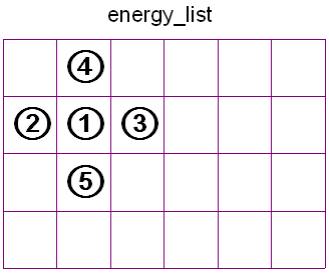


Fig. 13. Calculate Energy List using Euclidian Distance between the Color Index of the Pixel in Concern and the Four Neighboring Pixels.

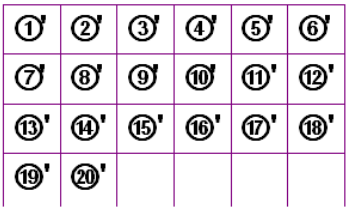


Fig. 14. Pixels in the m List is Aligned.

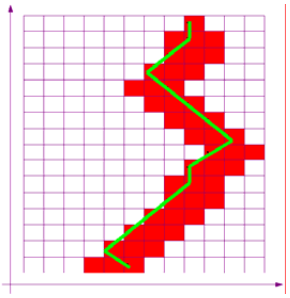
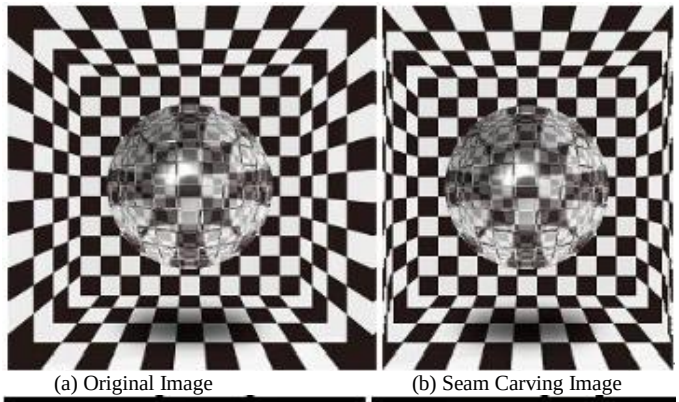


Fig. 15. Seam Carving Portion is Extracted Referencing to Energy List and m List.

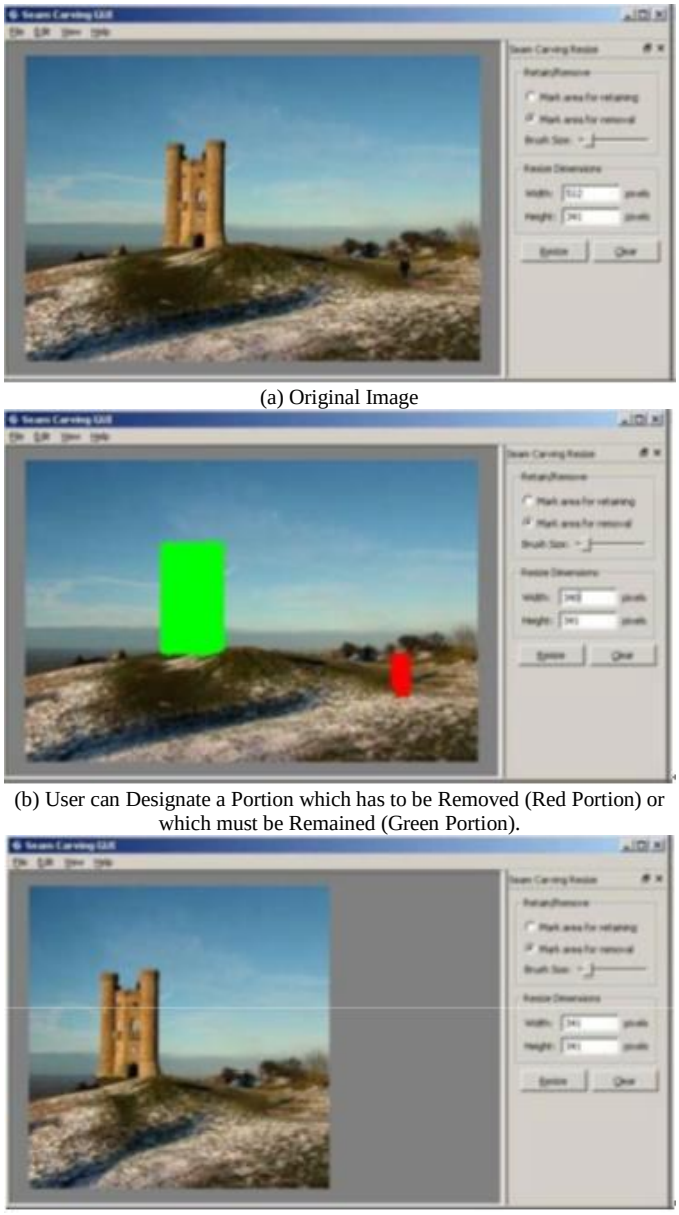


(a) Original Image (b) Seam Carving Image

(c) Original Image (d) Seam Carving Image

(e) Original Image (f) Seam Carved Image

Fig. 16. Other Examples of Space Domain Seam Carving.



(a) Original Image

(b) User can Designate a Portion which has to be Removed (Red Portion) or which must be Remained (Green Portion).

(c) Resized Image

Fig. 17. Example of Image Resizing with Intentional Condition on whether Remove the Image Portions.

ACKNOWLEDGMENT

The author would like to thank Mr. Hiroya Inoue for his effort through the experiments of seam carving programming.

REFERENCES

[1] Kwatra V., Schodl A., Essa I., Turk G., and Bobick A., Graphcut textures: image and video synthesis using graph cuts, ACM Trans. Graph. 22, 3, 277–286, 2003.

[2] Image Retargeting was invented by Vidya Setlur, Saeko Takage, Ramesh Raskar, Michael Gleicher and Bruce Gooch in 2005 http://en.wikipedia.org/wiki/Seam_carving.

[3] Boykov Y., and Kolmogorov V., An experimental comparison of min-cut/max-flow algorithms for energy minimization in vision, IEEE Transactions on Pattern Analysis and Machine Intelligence 26, 9, 1124–1137, 2004.

[4] Wang J., Bhat P., Colburn R. A., Agrawala M., and Cohen M. F., Interactive video cutout, ACM Trans. Graph. 24, 3, 585–594 2005.

[5] Lombaert H., Sun Y., Grady L., and Xu C., A multilevel banded graph cuts method for fast image segmentation, In Proceedings of the Tenth IEEE International Conference on Computer Vision (ICCV'05), vol. 1, 259–265, 2005.

[6] Liu F., and Gleicher M., Video retargeting, automating pan and scan, In MULTIMEDIA '06: Proceedings of the 14th annual ACM international conference on Multimedia, ACM, 241–250, 2006.

[7] Kohli P., and Torp P. H. S., Dynamic graph cuts for efficient inference in Markov random fields, IEEE Trans. Pattern Analysis and Machine Intelligence (PAMI) 29, 12, 2079–2088, 2007.

[8] Rav-Acha A., Pritch Y., Lischinski D., and Peleg S., Dynamosaicing: Mosaicing of dynamic scenes, IEEE Trans. Pattern Analysis and Machine Intelligence (PAMI) 29, 10, 1789–1801, 2007.

[9] Wolf L., Guttmann M., and Cohen-or D., Nonhomogeneous content-driven video-retargeting, In Proceedings of the Eleventh IEEE International Conference on Computer Vision (ICCV '07), 1–6, 2007.

[10] Shai Avidan Ariel Shamir, Seam carving for content-aware image resizing, ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2007, 26, 3, 10, 2007.

[11] Chen B., and Sen P., Video carving, In Short Papers Proceedings of Eurographics. 2008.

[12] Chen-Kuo Chiang, Shu-Fan Wang, Yi-Ling Chen, Shang-Hong Lai, Fast JND-Based Video Carving With GPU Acceleration for Real-Time Video Retargeting, IEEE Transactions on Circuits and Systems for Video Technology,, 19, 11, 1588-1597, 2009.

[13] The Open Computer Vision Library has more than 500 algorithms, documentation and sample code for real time computer vision. Tutorial documentation is in O'Reilly Book: Learning OpenCV http://www.amazon.com/Learning-OpenCV-Computer-Vision-Library/dp/0596516134

[14] Bhattacharyya, A., On a measure of divergence between two statistical populations defined by their probability distributions. Bulletin of the Calcutta Mathematical Society 35: 99–109, 1943.

[15] Starting with version 3.7, POV-Ray is released under the AGPL3 (or later) license and thus is Free Softwar http://www.povray.org/download/

AUTHOR'S PROFILE

Kohei Arai, He received BS, MS and PhD degrees in 1972, 1974 and 1982, respectively. He was with The Institute for Industrial Science and Technology of the University of Tokyo from April 1974 to December 1978 also was with National Space Development Agency of Japan from January, 1979 to March, 1990. During from 1985 to 1987, he was with Canada Centre for Remote Sensing as a Post Doctoral Fellow of National Science and Engineering Research Council of Canada. He moved to Saga University as a Professor in Department of Information Science on April 1990. He was a councilor for the Aeronautics and Space related to the Technology Committee of the Ministry of Science and Technology during from 1998 to 2000. He was a councilor of Saga University for 2002 and 2003. He also was an executive councilor for the Remote Sensing Society of Japan for 2003 to 2005. He is an Adjunct Professor of University of Arizona, USA since 1998. He also is Vice Chairman of the Science Commission "A" of ICSU/COSPAR since 2008 then he is now award committee member of ICSU/COSPAR. He wrote 37 books and published 570 journal papers. He received 30 of awards including ICSU/COSPAR Vikram Sarabhai Medal in 2016, and Science award of Ministry of Mister of Education of Japan in 2015. He is now Editor-in-Chief of IJACSA and IJISA. http://teagis.ip.is.saga-u.ac.jp/index.html